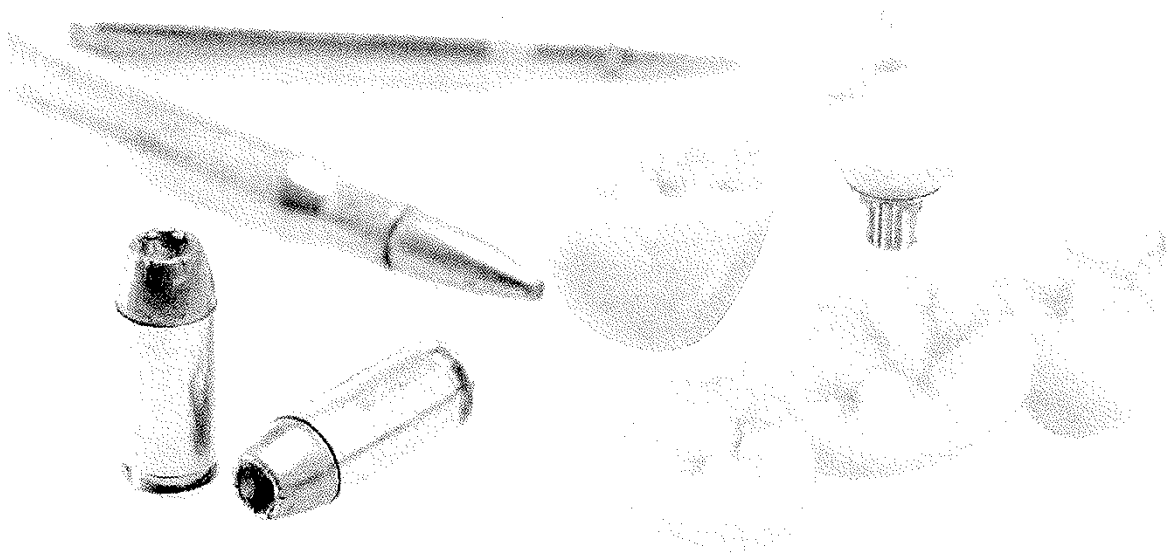


R&D Corner

BruxZir®: Virtually Bulletproof What Is It? Why Does it Work?



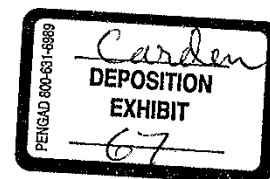
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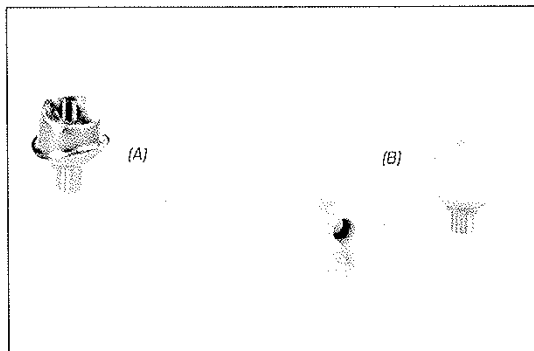


by Robin A. Carden

Zirconia has been a popular dental material for the last several years for many reasons. It is used to create copings for crowns, frameworks for bridges and custom implant abutments for implant cases. Glidewell Laboratories has recently introduced BruxZir® Solid Zirconia, a full-contour zirconia restoration with no porcelain overlay. Made from zirconium oxide powder, this advanced material has been refined to produce the strongest and most reliable all-ceramic to date. This article provides a material science overview of zirconium dioxide (ZrO_2), one of the most studied ceramic materials in the world.

Also known as zirconium oxide or zirconia, it is commercially available in two basic forms: naturally, as the mineral Baddeleyite, and synthetically, as derived from zircon sand ($ZrSiO_4$). Zirconia powder (zirconium oxide, ZrO_2) is synthesized from zircon sand ($ZrO_2 \cdot SiO_2$) using a solid-state reaction process. Several oxides are added to zirconia to stabilize the tetragonal and/or cubic phases: magnesium oxide (MgO), yttrium oxide (Y_2O_3), calcium oxide (CaO) and cerium (III) oxide (CE_2O_3), among others. Zirconia is a unique advanced ceramic, a chemical compound having the formula ZrO_2 . BruxZir is manufactured from yttria-stabilized





(A) Inclusive Titanium Abutment and BruxZir crown. (B) One piece screw-retained BruxZir with titanium insert.

The fracture toughness, or K_{1C} value, for partially stabilized zirconia is high because of a unique event called phase transformation toughening.

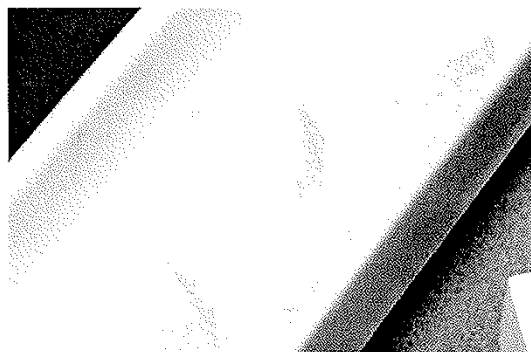
zirconia (YSZ) powder, which exhibits superior mechanical properties such as high strength and flexibility. A technological breakthrough, YSZ surpasses the strength limitations of traditional fine ceramics. The yttria-stabilized zirconia has potential for use in a wide variety of applications—everything from telecommunications to the new energy of the future to environmentally friendly products.

Partially stabilized zirconia is an ideal material for dental restorations like BruxZir because of the four physical properties it exhibits.

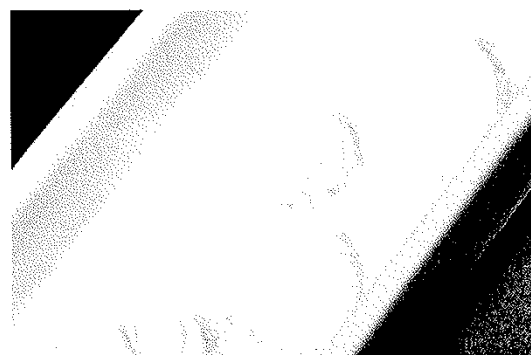
The first is high flexural strength. Typical zirconia materials have a flexural strength of more than 1,200 MPa. However, because of post-powder processing, BruxZir Solid Zirconia dental restorations are able to exceed that strength threshold, with flexural strengths up to 1,465 MPa.

The second is high fracture toughness, or K_{1C} value. For example, a piece of lead or steel has high fracture toughness; glass or brittle materials have a low value. The fracture toughness for partially stabilized zirconia is high because of a unique event known as phase transformation toughening that occurs in the material. The toughening mechanism comes into play when a crack is encountered. The cubic grains are constraining the tetragonal precipitates that want to expand and release associated energy. When these grains are faced with a propagating crack tip, the tetragonal phase is released and allowed to change back to the more stable monoclinic phase. This results in the associated volumetric expansion, effectively closing the advancing crack. A kind of self-healing event occurs. This also means the material has high impact resistance.

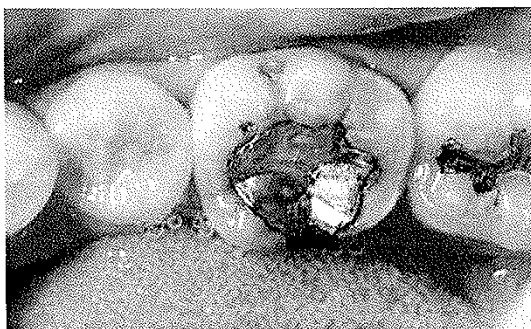
The third property is excellent resistance to thermal shock. Zirconia has relatively low thermal expansion numbers, which means it will remain very stable in the mouth.



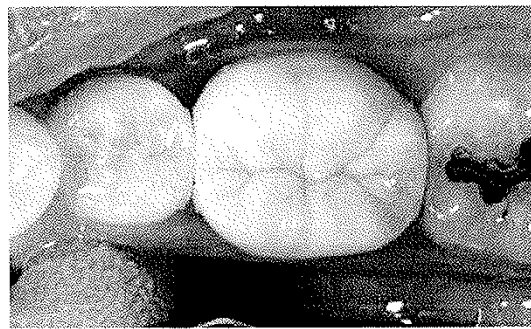
Unsintered BruxZir Solid Zirconia crowns (intaglio surface)



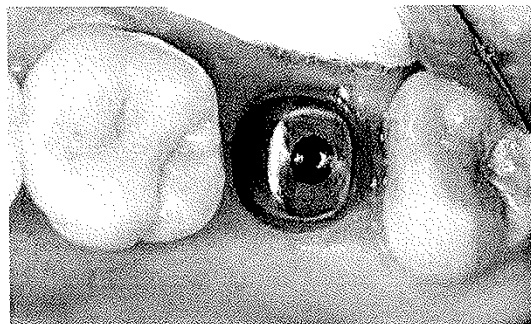
Unsintered BruxZir Solid Zirconia crowns (occlusal surface)



This patient presented with a failing amalgam restoration.



BruxZir Solid Zirconia crown shown on a natural abutment



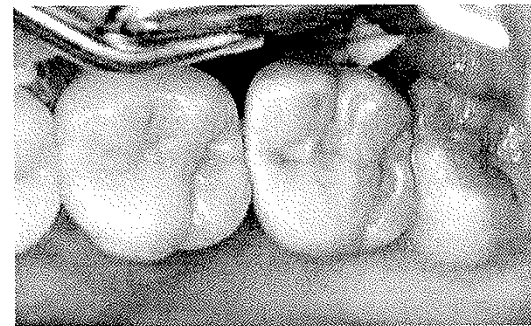
Inclusive Custom Titanium Implant Abutment



BruxZir Solid Zirconia crown

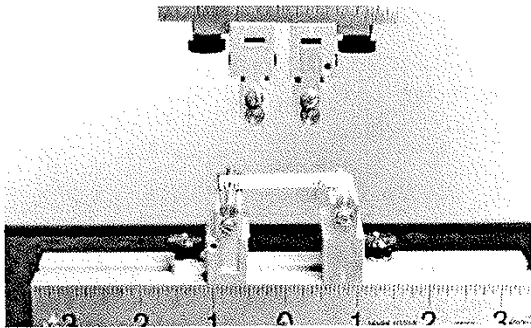


Screw-retained BruxZir Solid Zirconia crown

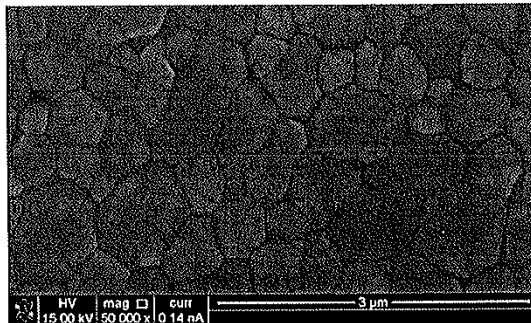


Screw access opening sealed

In looking to create the strongest zirconia in the world, we found something else has happened: We created a zirconia with improved translucency.



This Instron machine provides the measurement of a material's mechanical properties, including flexural, fracture and tensile strength.



This SEM machine photo exhibits the crystalline structure of zirconia.

The fourth, and most innovative, is color and translucency. Zirconia has a natural opaque white hue, but Glidewell Laboratories has recorded advancements that allow zirconia to be changed into a more desirable translucent natural ivory shade. This shade is much more lifelike than typical snow-white zirconia. The lab's scientists start with the most pure powders available and create better chemistry by refining particulates via size reduction and blending.

The laboratory then creates a green pre-form with very high pre-bisque firing density by using unique consolidation processes. These processes allow the smallest particulates to be as close as possible before the machining starts. By doing this, the lab also reduces the elongation factor, which means a more accurate crown dimension. After machining, the part is sintered to full density. By using these processes and refining the starting powder, we are able to create a material that has small grain size, which improves flexural strength and fracture toughness. As a crack moves through a material's grain boundaries it is deflected by the material's grains. If a material has many grains to deflect and take energy out of the force of the crack, it becomes inherently stronger. But in looking to create the strongest zirconia in the world, we found something else has happened: We created a zirconia with improved translucency. Focusing on smaller particulates created better translucency. And BruxZir Solid Zirconia has a higher translucency than other dental zirconias.

Getting back to the workings of the material, in the field of mechanical properties, strength and toughness are related as follows. Brittle materials may exhibit significant tensile strength by supporting a static load. Toughness, however, indicates how much energy a material can absorb before mechanical failure. Fracture toughness is a property that describes the ability of a material with inherent microstructural flaws to resist fracture via crack growth and propagation. Methods have been devised to modify the yield strength, ductility and fracture toughness of both crystalline and amorphous materials. Fracture toughness is a quantitative way of expressing a brittle material's resistance to fracture when a crack is present. This is one of the most important properties of any brittle material for virtually all design applications. If a material has a high value of fracture toughness, it will probably undergo ductile fracture. Brittle fracture is very characteristic of most ceramic and glass-ceramic materials, which typically exhibit low and inconsistent fracture toughness.

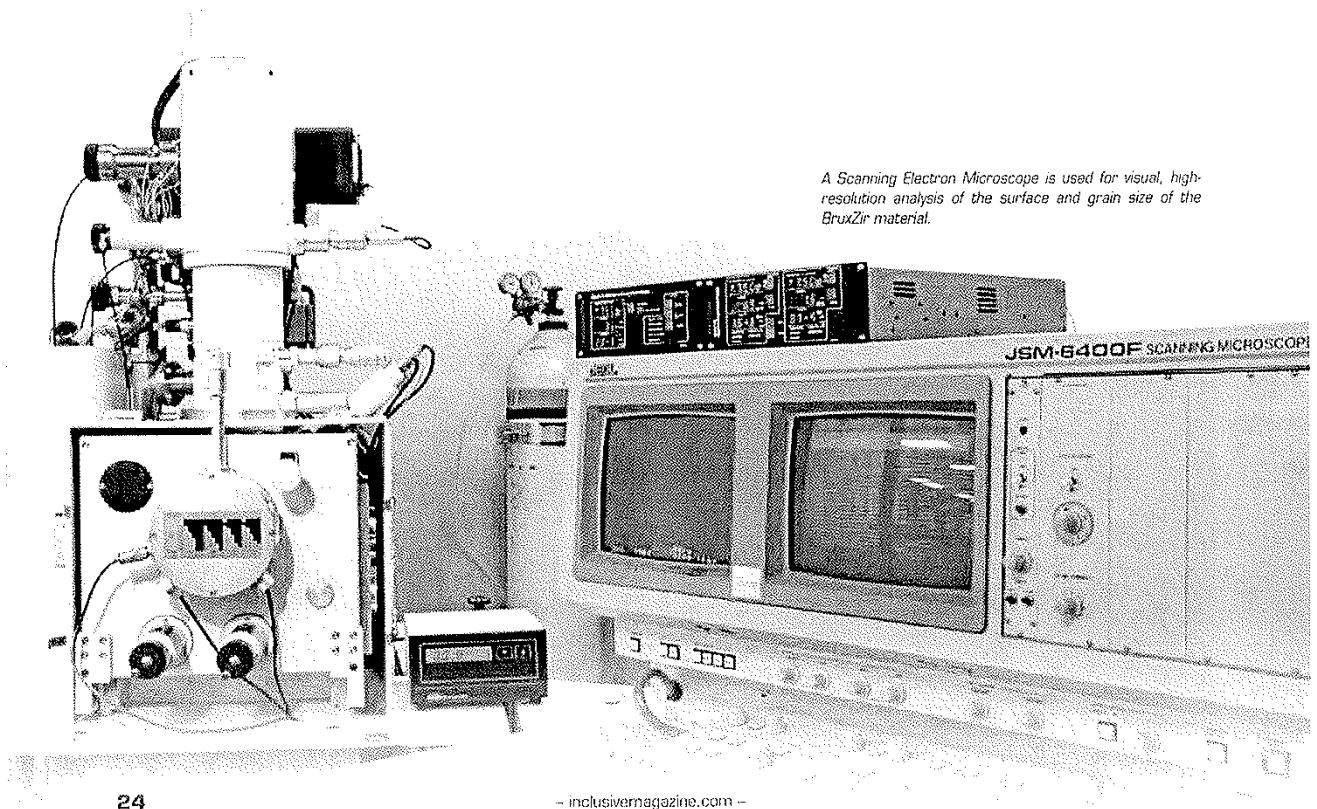
Transformation toughening was a breakthrough in achieving high-strength ceramic materials with a high value for fracture toughness. For the first time, a ceramic material was available with an internal mechanism for actually inhibiting crack propagation. A crack in a traditional ceramic travels all the way through the ceramic with little inhibition, resulting in immediate and brittle fracture and catastrophic failure. The partially stabilized zirconia

exhibits a fracture toughness that is three to six times higher than normal zirconia and most other ceramics. Partially stabilized zirconia is so tough that it can be struck with a hammer or even fabricated into a hammer for driving nails.

These innovations led to the development of BruxZir Solid Zirconia, which is indicated for bruxers and grinders as an esthetic posterior alternative to metal occlusal PFMs or cast-metal restorations. Designed and milled using CAD/CAM technology, BruxZir is sintered for 6.5 hours at 1,530 degrees Celsius. The final BruxZir crown or bridge emerges nearly chip-proof and is diamond polished and glazed to a smooth surface.

Another beneficial physical characteristic of BruxZir is its wear properties. The Glidewell R&D team has determined that diamond polishing the BruxZir crown provides long-term life for opposing enamel surfaces. This wear compatibility has been validated in enamel wear "in-vitro" studies, and clinical studies are currently under way as well.

To learn more about BruxZir® Solid Zirconia or to find a lab that offers it, visit bruxzir.com or call 800-854-7256.



A Scanning Electron Microscope is used for visual, high-resolution analysis of the surface and grain size of the BruxZir material.